

INTERIM PROGRESS REPORT
STUDY, DESIGN, AND FABRICATION OF ANAMORPHIC
VIEWING SYSTEM



25X1

PERIOD 1 JULY TO 10 AUGUST 1965

Declass Review by NGA.

Prepared by:

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ALL US

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August 24, 1965

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[Redacted]
Post Office Box 9642
Rosslyn Station
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Attention: Ed D.
Subject: Transmittal of Documents

Gentlemen:

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[Redacted] herein submits, in triplicate, our Interim
Progress Report in accordance with the terms of Contract

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[Redacted] This report covers the first six weeks
of a three month study phase.

If you have any questions concerning this project, please
contact the writer directly.

Very truly yours,

25X1

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[Redacted]
Encs. (3)

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cc: Contracting Officer
Encs.(2)

Group 1
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1 INTRODUCTION

This report describes the work performed during the first six week period under contract [] for study, design, and fabrication of one pair of anamorphic eyepieces or one anamorphic optical system. The purpose of this program is to develop a viewing system having variable anamorphism using the basic configuration of the Zoom 70 Stereoviewer. Hopefully the result of this program will be an eyepiece type attachment, which will be adaptable to other stereoviewing instruments as well as the Zoom 70. Consideration is not restricted to attachment type devices, and if necessary the Zoom 70 configuration will be modified to achieve the desired result.

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The initial six week period has been concentrated on a preliminary review of the optical problems associated with various attachment type devices and with various possible modifications of the Zoom 70 Stereoviewer. Purpose of this was two fold. Hopefully in doing this a satisfactory solution might be found almost immediately thus sharply curtailing the length of the program. Failing in this, however, the preliminary evaluation of all techniques showed where the most serious problem areas existed, how complex they are, and thereby furnished direction to the second six week phase.

As expected this cursory review has not resulted in a completely satisfactory solution. As will be discussed later a possible solution has been found which has some undesirable features. It will now be necessary to obtain whatever other

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solutions exist, evaluate the relative advantages and disadvantages of each, and on the basis of comparison select the technique having the greatest number of advantages.

2.0 STUDY RESULTS

Here the various portions of the preliminary review are discussed, and the main conclusions reached are stated.

2.1 CYLINDRICAL ABERRATIONS

Previous attempts to design variable anamorphic viewing systems have been hampered by lack of knowledge of the optical performance of cylinder lenses in convergent light. Since it was known that cylinder lenses have the same aberrations as spherical lenses in collimated light previous anamorphic systems have included a collimating system ahead of the cylindrical components. The collimating system caused the resulting system to be excessively long. If the cylindrical system could be designed to operate in convergent light, thus eliminating the need for a collimating system, it was felt that a substantial reduction in length could be achieved. Since the answer to this question would drastically influence the course of the program it was the first item studied.

A literature search was made to determine what had been done in the past in the design of anamorphic systems in convergent light. Only a limited number of references were found. However, enough information was found to strongly indicate that for the relatively low angle of convergence associated with the bundle of light coming from the Zoom 70 objective system there will be no difficulty with the aberrations which are unique to cylindrical lenses. Thus it should be possible to design the system

using the conventional techniques of spherical systems. These conclusions are based on a third order aberration theory, and the approximations involved should hold quite well in the present case.

To remove any element of doubt we are currently trying to set up a well corrected spherical system as a cylindrical system for detailed, accurate ray trace analysis. The results of such analysis will firmly establish whether cylindrical lenses can be used without a collimating lens. In the meantime we are sufficiently confident of the conclusions reached from the literature study that the study of possible arrangements is being based on it.

There are certain additional complications which enter when the cylinder lens system is used in convergent light. This is the fact that extra effort is necessary to assure that the images formed by the power and the no-power directions of the cylinders are in the same plane. In the case of the collimating system this was automatically the case if the cylinder portion of the system was truly afocal. In the present case it appears, as will be discussed shortly, that two sets of cylinder lenses with power planes at right angles will be necessary.

2.2 ATTACHMENT TYPE DEVICES

The ideal solution to the anamorphic viewing system problem would be a device that fits in the eyepiece tube, and is readily interchangeable with the standard eyepiece. It is also desirable that if such a device could be achieved all components

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should be above the image plane of the Zoom 70 objective system. The unit would then be directly interchangeable with eyepieces of other stereoviewers.

It is apparent that this idealized solution will not be achieved. Exhaustive review of our catalogue of zoom lens solutions has shown that there is no zoom system that will fit within the roughly one inch space between the object plane and optical components of a 10X eyepiece. Nothing worthwhile can be gained by using a spherical eyepiece of lower power, and maintaining the 10X overall power by crossed cylinder systems. One might for instance visualize a 5X spherical eyepiece combined with a cylindrical zoom system ranging from 2 to 4.4. This would give the desired 10X to 22X power range. In this case, however, one must introduce a fixed, 2X power, cylinder system with power planes at right angles to the zoom system. As soon as this is tried the requirements on space increase, and the extra length gained by use of a lower power eyepiece is more than lost by the requirement for a fixed cylinder system. Thus we have been forced to restrict consideration to those systems having optical components below the image plane, and which will, therefore, not be interchangeable with other instruments where there is no space below the image plane.

Another desirable feature would be to have the zoom cylindrical system form its final image in the same plane as the object. In this case the final image formed by the cylindrical power would lie in the same plane as the image formed in the no power plane. Unfortunately it has not been possible to find a

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zoom system meeting this requirement within the space available to fit it, and having lens power distribution that would prove practical at the final correction stage of design.

Thus it has been necessary to seek a design which shifts the image somewhat, and introduce a fixed cross cylinder system that will shift the image in the no power direction of the zoom system to the same plane as the image formed by the zoom system. Such a system has been obtained. It is at this stage only a system of thin lenses. No attempt has been made to correct this system although we can see no insurmountable problems in obtaining a final design. It has the disadvantage that the final image viewed by the spherical portion of the system is virtual so that no physical fixed stop can be introduced to limit the field. Also one lens at one point in the zoom range moves through the image plane. This might be disturbing to user, but is not considered cause for rejection of the system.

First order analysis has indicated that the eye relief will probably be of the order of ten millimeters. The pupil shift through the zoom range may be as much as 6 mm. This would of course result in two exit pupils (one formed by the zoom portion and the other by the fixed portion) displaced along the axis by this amount. This is presently considered only border line acceptable.

Thus one system has been found that meets the requirements. There are certain disadvantages to it, and it is desirable to determine whether other solution with fewer disadvantages may exist.

A second system composed completely of cylindrical lenses (no spherical components either in the fixed or zooming portion) is being studied. In this system the exit pupil variation has so far been the most difficult to resolve. In fact no first order solution has been achieved as yet. However, steady progress is being made, and it is considered worth while to continue consideration of this type system for a while longer.

2.3 ZOOM 70 MODIFICATION

As noted previously there are certain advantages to placing the zoom system in collimated light. Despite the fact that it now appears possible to design the cylinder system in convergent light there would still be advantages to the use a collimator in the system. If a negative collimator could be used the problem of image inversion would be eliminated. Introduction of such a collimator at the dust cover had been previously considered and found to lead to excessive loss of field. Without serious modification it would be possible to place a negative collimator between the mirror cluster and the zoom lenses of the Zoom 70. This has been investigated, and while it is a definite improvement over positioning the collimating lens at the dust cover there is still an unsatisfactory loss of field.

The next step has been to determine what could be done by changing the mirror cluster. The purpose of this cluster at the present time is to erect the image as well as to furnish interpupillary adjustment. If it were to be replaced by a simple two mirror rhomb arrangement the image would be inverted,

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and the previously developed system would then provide an erect image. At present the mirror cluster takes up about four inches of optical path and any system used to replace it must either take up this path or the final image will be formed much further from the instrument than at present. Thus the viewing point would be extended much more than the desired four inches.

Another possibility is to place a negative collimator between the mirror cluster and the Zoom 70 zoom lens as above. In the present case, however, the mirror cluster would be removed so that the cylindrical zoom system could be placed near the collimating lens. The field size could then be maintained, and a system similar to that previously built could be used. The final image in this case would be inverted and hence unsatisfactory. To correct this a single mirror would replace the mirror cluster, and an image rotation device such as a Pechan or K mirror would be introduced in the system. The single mirror would aid in the erection of the image, and would provide a mechanism for interpupillary adjustment.

While there are several possibilities in the area of instrument modification none of them seem to be ideal. The ones discussed above seem promising, but require lay out to see exactly how they will fit the instrument. This is being done, but to date no results have been obtained.

2.4 PRISM SYSTEM

It is well known that small prisms can be used to provide anamorphism. The suitability of this type system in convergent

light is not known. A prism system designed to work over a range of 2.2 to 1 has been designed. It was expected that analysis of this system in convergent would be completed and the results included in this report. The problem of programming the computer to trace rays through prism systems has proven more difficult than anticipated. Good progress on this problem is being made and it is expected that it will be resolved shortly.

Such a system is highly desirable since alignment is nowhere near as critical as in cylinder systems. One can foresee a multitude of problems in aligning systems of crossed cylinders such as discussed above.

4.0 FUTURE PLANS

We will continue the investigation of what can be achieved by modifying the Zoom 70 by removal of the mirror cluster. There are many features of the system using a collimator that are very appealing. Since the problems with this system are primarily those of spacing and arrangement the study will consist of laying out various arrangements to see how they fit requirements of the contract.

Analysis of the prism system in convergent light will be made. Also the conclusion that cylinder lenses can be used without a collimating lens will be verified by analysis of a spherical system set up as a cylindrical system.

There will be continued creative effort to determine whether there is some system not yet thought of that may provide a solution to this problem. This is, of course, essentially asking for invention on demand. While chances of success are slim the problem is proving so difficult that every avenue of solution must be considered.